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No. IX.

Remarks on the Sandstone and Flötz Trap Formations of the Western Part of the Valley of the Mississippi. By E. P. James, attached to the Exploring Expedition commanded by Major S. H. Long, of the United States Engineers. And by the Major communicated to the Society, with the permission of the Hon. J. C. Calhoun, Secretary of War.—Read (in conjunction with the preceding Number) on the 17th of August, 1821.

THE district of country contemplated in the following Essay, lies on the south western margin of that great valley which is watered by the Mississippi and its numerous tributaries. We have confined our attention to that tract which lies south of the river Platte, and west of a meridian line intersecting the Arkansaw at the confluence of the Ne-gracka.

Towards the West, our examinations have been terminated by the first ranges of the Rocky Mountains ; and by Red River on the south.

E. P. JAMES.

Smithland, Kentucky, 12th April, 1821.

It is remarked by Maclure and others, who have made the requisite comparisons, that the rocky formations of North America appear less disturbed and confused than those of Europe. If this be the case with that part of the country which has been examined by the above mentioned philosopher, it is perhaps more so with a large and interesting portion of it hitherto little known to the geologists of Europe or America. I refer to that extensive plain, a part of which contains the bed of the Mississippi and its tributaries, and to the stupendous range of mountains which constitute its western boundary.

These mountains have by some been considered as a continuation of the great chain of the Andes ; and in conformity to this opinion, the name has been extended to them. It is to be regretted, that common consent has not as yet established a distinctive appellation for this important range. Snowy, Rocky, Shining, Chippewan, Sandy, Missouri, Caous, and Mexican, are a few among the attributives hitherto bestowed upon it. It is to be hoped that one of these, or some other, may finally gain the ascendancy, and it is of little importance which it shall be.

The general direction of the range is from north west to south east. It extends from near the Gulf of Mexico on the south east to the Northern Ocean at the mouth of Mackenzies River on the north west.

It will be proper first to direct our attention to the great plain, or, as it has been called, the Valley, of the Mississippi, which must be considered as commencing near the summit of the Alleghany Mountains, and stretching westward to the feet of the northern Andes. In this region, the observer discovers few traces of those tremendous upturnings and commotions whose history is so plainly written on the rocky strata in the eastern part of the continent. Until he arrives within a few leagues of the Rocky Mountains, he finds all the materials constituting the surface resting undisturbed in their original position. The rocks are almost universally stratified, and their stratifications commonly maintain a pa-

parallelism with the horizon. The slight inequalities of the surface are often manifestly the effects of water, which running for ages over a light and loose soil, have hollowed for themselves channels and valleys proportioned to their size and velocity. Wherever these currents, or other causes, have laid bare the rocky substrata of the soil, the remains of marine animals are found incorporated in the body of the rock. They are also met with in most perfect preservation in the soil.

These appearances afford sufficient evidence, that at some remote period the waters of the ocean rested upon this extensive region.

Proceeding westward from the Mississippi, the surface rises gradually, having however inclination sufficient to give to many of the streams which traverse that part of the country a velocity of near six miles per hour. This inclination seems to be greatest in the neighbourhood of the Missouri, as that river, the Quicurre, Platte, &c. have a much more rapid current than the Arkansaw and the south western tributaries of the Mississippi. The country bordering on the Mississippi is for the most part deeply covered with soil, which supports a profuse vegetation. To the north and west it differs little from one extensive savanna. The traveller journeys, for weeks in succession, over a dreary and monotonous plain, sparingly skirted and striped with narrow undulating lines of timber, which grow only along the margins of considerable streams of water. In these boundless oceans of grass, his sensations are not unlike those of the mariner, who beholds around him only the expanse of the sky and the waste of waters.

The Missouri, between the Mississippi and the mouth of the Platte, passes through some considerably extensive fields of compact limestone, sandstone, and other horizontally stratified rocks. On the Platte, no rocky formations appear within about four hundred miles from its confluence with the Missouri. At about this distance, some inconsiderable

ridges of coarse friable sandstone occur. These hills, though irregular in direction, appear to range from north to south. They may perhaps be a continuation from the Côtes Noires, or Black Hills, which are situated farther to the north, and are said to contain the sources of the Shian, the Little Missouri, and some branches of the Yellowstone. *Lewis and Clark's Hist. Vol. I. p. 183.* The strata which compose these hills are not inclined, and their appearance indicates recent marine origin. The only rock which I have met with here is sandstone, of a kind not unlike that which usually accompanies coal. This inconsiderable tract being passed, the surface again subsides to a plain; but is more barren and gravelly than before. Instead of the fine and somewhat fertile sand which prevails to the east of the above mentioned ridge, the surface is here almost entirely made up of small pebbles and gravel. The soil is of course barren.

From this plain the Rocky Mountains are first seen at a distance, in some states of the atmosphere, exceeding one hundred miles. They first discover themselves, not by emerging from below the sensible horizon, but become distinguishable from the clouds and the sky above it. Their snowy and shining summits, when first seen, were mistaken for clouds by almost every individual of our party. On approaching such considerable elevations, it is not uncommon to look for great changes in the structure and materials of the surface. But here none such are seen until you arrive at the very foot of the mountain. Where the Platte first enters the plains, the horizontal strata of sandstone extend to within five miles of the commencement of the high granitic ridge which forms the first barrier of the Rocky Mountains. On the Cannon-ball River, eight miles above its confluence with the Platte, and less than one-third of that distance from the granitic ridge just mentioned, are several ranges of small hills running parallel to the general direction of the mountain, and extending to the northward for a considerable dis-

tance. Where these have been cut through by the bed of the river, they are found to consist of a soft horizontal sandstone abounding in mica.

In a somewhat elevated district, a little to the south of the immediate valley of the Platte, similar ridges occur, at a greater distance from the primitive mountains.

After passing numerous small and rounded hills, whose surface is chiefly composed of gravel, sometimes intermixed with rolled masses of granite and other similar rocks, there is seen a range of naked perpendicular and lofty rocks, rising from the naked plain at the very foot of the mountain, and presenting to the eye the forms of walls, columns, pyramids, &c. These, when minutely examined, appear to be of the same sand rock found so abundantly in the plains differing from it however in the particular of that great inclination which its strata in this instance possess. These ranges appear to be formed by the margin of the strata of sandstone which occupy the plain; this margin, by the violent operation of some unknown cause, having been broken off from the body of the stratum and thrown into the perpendicular position in which it is now seen. Climbing to the summits of these ridges, and crossing their stratifications in a direction towards the primitive, appearances occur similar to what are seen in the same rocks remaining in their original position, when circumstances enable us to push our inquiries at any considerable distance below the surface. Having crossed the upturned margin of the whole secondary formation which occupies the plains, and arriving at the primitive, an unexperienced geologist will perhaps be surprised to find these rocks, so evidently of recent marine origin, reposing immediately against the granite. Previously formed opinions may have induced him to expect appearances which he will not here find. He will search in vain for any traces of those rocks which occupy so conspicuous a place in the works of systematic geologists, denominated rocks of transition. He may also be surprised at the total absence of those primitive strata which the theory of universal forma-

tions may have taught him to look for above the granite. He will find recent marine sandstone abounding in organised remains, with its stratifications nearly perpendicular, and in immediate contact with the side of a granitic mountain of vast magnitude and elevation, and of a character most manifestly and highly primitive. The inclination of the strata of this sandstone varies within a short distance from horizontal to an angle of more than sixty degrees. It is sometimes difficult to determine, by the eye alone, which way it varies from an exact perpendicular. Those laminæ or strata of it, which are most distant from the primitive occupying the eastern ridges of its first elevations, have the least inclination, and may with propriety be denominated the uppermost. At the level of the surface of the great plain they sink beneath the alluvial, and in the immediate neighbourhood of the river Platte they are no more seen. The uppermost are of a yellowish grey colour, moderately fine, compact, and hard, constantly varying however at different points in colour, as well as most other characters. The light coloured varieties frequently contain numerous small round masses of about the size of a musket ball, which are more friable than the rock in which they are imbedded, and from which they are easily detached, leaving cavities corresponding to their own shape and dimensions. They are commonly of a dark brown colour, and of a coarser sand than that which enters into the composition of the rock itself. Mr. Say informed me that their appearance was not unlike that of certain organic remains of the Genus *Ovulite*. Where these are found, I could never discover any of those numerous animal relicts which are so common in many of the secondary rocks of this district.

Crossing the edge of these strata of sandstone, the character of the rock is found to change, on coming nearer to the primitive. The rock becomes more coarse and friable, its colour inclining more to several shades of red and brown. This variety contains numerous masses of iron ore, and does not appear to abound in the remains or impressions of orga-

nised beings. It is also less distinctly stratified than the variety before mentioned, and contains many beds of pudding-stone (le poudingue of Brochant.) These beds are sometimes of great extent, but certainly cannot be considered as constituting a stratum distinct from the sandrock. This tract of inclined sandstone, which skirts the eastern boundary of the Rocky Mountains, and which we have considered as constituting a part of that immense formation of secondary which occupies the valley of the Mississippi, abounds in scenery of a grand and interesting character. The great inclination of the strata we have before noticed. That side of the ridges which is nearest the primitive, appears as if broken off from a part of the stratum beyond, and is usually an abrupt perpendicular precipice, sometimes overhanging and sheltering a considerable extent of surface. The upper part of the stratum, or that surface which is most distant from the primitive, is usually smooth and hard, and both sides are alike destitute of soil and verdure. Elevations of this sort are met with varying from twenty to several thousand feet in thickness. Nor are they by any means uniform in height. Some of them rise probably three or four hundred feet, and considering their singular character, would be high, were they not subjected to an immediate and disadvantageous comparison with the towering Andes at whose feet they are placed. Their summits, which in some instances are regular and horizontal, are crowned with a scanty growth of cedars and pines. Where the cement, and most of the materials which constitute the sandstone, are silicious, the rock evinces a tendency to separate in fragments of a rhombic form: and in this instance the elevated edge often presents a notched or serrated surface. Those sandstones which consist of silex with the least intermixture of foreign ingredients are the most durable. But in the region which we are now considering, the variations in the composition, character, and cement of the sandrock, are innumerable. Clay and oxide

of iron abound principally in those varieties nearest the granite, which are usually of a reddish colour. When these enter into the composition of the rock in certain proportions, they seem to disqualify it for withstanding the attacks of the various agents, whose effect is to hasten dissolution and decay. Highly elevated rocks of this description may well be supposed in a state of rapid and perceptible change. The sharp angles and asperities of surface which they may have originally presented, are soon worn away. The matter which is constantly removed, by the agency of water, from their sides and summits, is deposited at their feet; their elevation gradually diminishes, and even the inclination of their strata becomes obscure, or is rendered wholly undiscoverable. A soil is at length formed over the whole surface, which gives support to a covering of vegetables. This is probably the process by which have been formed the numerous conic hills and mounds, that are now seen interspersed among the highly inclined naked rocks of which I have been speaking. These hills, often clothed with considerable verdure to their very summits, add greatly to the beauty of the surrounding scenery. The contrast of colours which is here seen, often produces the most brilliant and grateful effects. The deep green of the small procumbent cedars and junipers, with the less intense colours of various kinds of deciduous foliage, acquire new beauty by being placed as a margin to the glowing red and yellow which is seen on the surface of many of the rocks. In the narrow but verdant valleys, small pyramids and columns of the purest white are met with, standing solitary and detached from any surrounding rocks.

The district of country of which we have now been speaking may, without impropriety, be denominated the valley of the Platte, as the waters which flow from it are discharged into that river.

Near the summit of the small ridge which, running east from the Rocky Mountains, divides the waters of the Platte

from those of the Arkansaw, the sandstone district presents the following appearances, in traversing it from the east toward the primitive :

1. Compact, hard, yellowish grey sandstone, containing organised remains, but not in great abundance. This rock is inclined to the west, at an angle of about twenty degrees. It forms an inconsiderable, but continuous elevation, stretching along the foot of the mountains, from north to south, its western side exhibiting a perpendicular precipice.

2. In the valley between the last mentioned and the succeeding ridge, are several detached columns, of great height and thickness, standing perpendicular, and being irregularly dispersed through the narrow but woodless valley. These masses are usually of a deep red colour. They consist of sandstone of various degrees of fineness, the particles of which are held together by a cement of clay and oxide of iron. They have an irregular surface, which evidently owes its present form to the action of water ; and their summits are usually sharp. Several of them, though of great height and covering a considerable extent of surface, are so naked and steep on all sides, as to bid defiance to all attempts at climbing them.

At a short distance beyond these, is the commencement of the high primitive mountain. The beginning of the ascent upon this is covered by a thick bed of white pudding-stone, rising upon the side of the granite to an elevation of about two hundred feet above the little plain just mentioned. This rock, though commonly very coarse, contains small beds and stripes of the fineness of ordinary sandstone, in which there occur several small oval masses of yellowish and blueish white hornstone. On the surface of these masses, are the relicts of marine animals, mostly bivalves, in beautiful preservation. This rock also abounds in ironstone. From its eastern declivity about two hundred yards from the point at which the granite emerges, there issues a considerable spring of water, highly impregnated with muriate of

soda. The granite which here rises from beneath the secondary strata, is coarse, consisting of a large proportion of reddish brown feldspar in imperfect crystalline masses. The mica is black, and in small proportion. The granite is not compact, and decays rapidly. Being separated probably by the frost, it crumbles into small fragments, which roll down from its steep declivities and accumulate in great quantities in the small hollows and in the beds of streams. This rock rises abruptly to a vast elevation, and probably extends far to the west.

These appearances are found on the southernmost of those branches of the Platte which descend from the mountains before their junction with that river. Proceeding still southward, the sandstone ridges nearly disappear in the elevated tract which divides the waters of the Platte from those of the Arkansaw. The smooth and grassy plain is here terminated by brown and naked piles of granite, which rise almost perpendicularly into the regions of perpetual frost.

The secondary district which lies beyond this ridge, has a surface slightly inclined towards the north east, discharging in a contrary direction several small streams into the Arkansaw. The most striking feature of this region is constituted by certain moderately elevated tabular hills, with perpendicular sides and level summits, which are scattered irregularly about the country, adding greatly to its beauty. In ascending these hills, their sides are almost invariably found to be of coarse friable sandrock and loosely cemented, conglomerate. Above these, and forming the top of the hill, is usually a stratum of fine compact sandstone. It is also obvious, on the slightest examination, that in the sides of those hills which stand near each other, there are, at equal heights on each, corresponding stripes and beds similar in colour and other particulars. These appearances are so constant as to leave little doubt that the hills in question are the remains of a formation of coarse sandstone which may formerly have covered a great extent of the plain country bordering on the mountains. From the nature of the cement, the fineness

of the sand, or from other causes, insulated portions of the upper part of this formation have resisted the action of the water, and of the various agents which have broken down and removed the adjacent parts. These portions have protected and preserved entire the columns of loose sandstone on which they rested. One of these singular hills, called the Castle Rock, of which Mr. Seymour has preserved a sketch, when seen from a little distance, presents the appearance of columns, porticos, arches, &c., having a most striking resemblance to an architectural ruin.

One of the first considerable tributaries which the Arkansas receives from the north, after it enters the plains, is called the Boiling-spring Fork. It has received this name from a large and uncommonly beautiful spring of water, situated upon it immediately at the foot of the mountain. This spring is but a few rods from the commencement of the granite, which there rises into what is called by Pike the "highest peak," and issues from a chasm in a stratum of fine compact sandstone of a deep red colour, which reposes against the granite at an angle of near forty degrees. A short distance to the right, this sandstone is succeeded by an extensive bed of silicious breccia resting against the granite in a similar manner. This aggregate consists of coarse angular fragments of hornstone, jasper, and other silicious minerals, firmly cemented. It is also of a red colour, and abounds in iron.

The spring above mentioned throws out a considerable quantity of water, perhaps fifty gallons per minute, and also about an equal volume of an aeriform fluid. The water is limpid and colourless, and when freed by boiling from the carbonic acid which it contains, is entirely without taste. Immediately on coming in contact with the air, it is covered with a pellicle of carbonate of lime, which substance has been so copiously deposited as to form a capacious basin overhanging a considerable stream of water, and looks as if chiselled from the whitest marble. The rising of the

air through the water of this bason produces a constant and violent agitation similar to boiling.

When fresh from the spring, the water has the taste and appearance of the common soda water, and is, I believe, as highly impregnated with carbonic acid as it could be by the most powerful artificial means. It is extremely agreeable to the taste, and when drunk in the quantity of several pints, is followed by no sensible effects except a very considerable degree of exhilaration, which is immediate.

The general direction of the first ridge of the Rocky Mountains, from beyond the Platte to the Peak, is from north to south. A few miles south of the peak, this ridge abruptly terminates, sending out, in a south eastern direction a long range of low secondary hills. Crossing these in a south west direction, we found, that though broken and elevated, they consist almost entirely of horizontal sandstone. This rock is of a yellowish white or light grey colour, of an uncommonly slaty structure, and evidently contains a large proportion of clay. Organised remains are to be seen in it, but these are not numerous or conspicuous. It is traversed by narrow upright veins of carbonate of lime, in crystals. It contains horizontal beds of bituminous shale; and selenite is sparingly scattered over the surface. This formation of argillaceous sandstone extends far to the south and south west; it also occupies the large amphitheatre or bay which is formed between the main range of the mountains and the projecting spire which contains the high peak. At the extremity of this bay, the sandstone is red and highly inclined, similar to that on the Boiling-spring Fork; but this appears to dip under the argillaceous sandstone above mentioned. At the place where the red sandstone ridge is divided by the bed of the Arkansas, are several springs highly impregnated with muriate of soda, sulphate of magnesia, and probably several other soluble salts. They also emit carbonic acid and sulphuretted hydrogen gases. The water of these springs, except one, is nauseous to the taste, and their dis-

agreeable smell is perceptible at some distance. They are not like most of the saline springs frequented by herbivorous animals. They are six or seven in number, and all rise within a few yards of each other. The mineral substances which they hold in solution are probably nearly the same in each ; but the water of one of them is highly charged with fixed air, and for this reason is more agreeable to the taste. Their temperature appears to be that of the earth at a small distance below the surface. In the middle of July, the medium temperature of these springs, as well as of the great one at the foot of the peak abovementioned, appeared by several trials, to be about sixty-two degrees of *Fahr*. In the air the thermometer ranged from fifty to one hundred and four degrees. These springs have been called Bell's Springs, in compliment to captain John R. Bell, who visited them on the 18th of July, 1820. The sandrock from which they issue is rapidly succeeded by one still more fine and hard, and of a browner colour, alternating with each other, and resting against the perpendicular gneiss rock which there forms the commencement of the primitive, and beyond which it seems almost impossible to penetrate. It appears, however, from the Journal of that enterprising traveller, the late General Pike, that he entered the mountains at this place. The Arkansaw rushes with great violence of current from a narrow gap in this gneiss rock, and is then for a considerable distance confined to a narrow and deep valley bounded on both sides by precipitous walls of sandstone rising from one hundred to one hundred and fifty feet to the level of the great plain. These rocky banks are of the argillaceous sandstone before mentioned, and appear to extend sixty or seventy miles from the mountain. Where the exploring party forded the Arkansaw, about one hundred miles from the mountain, the country is not rocky, but rises very gradually from the river, till at the distance of six or eight miles it is broken by a few inconsiderable gravelly hills. A little distance from the considerable streams, it varies but little from

the country about the river Platte, which is an arid and sterile plain of sand and gravel.

From the Arkansaw to the sources of its longest tributary, the Canadian, is a distance of about one hundred and fifty miles in a direction nearly south. The district between these two rivers is nearly plain, but the small streams which traverse it are sunk in deep and narrow valleys terminated by precipices of sandstone similar to the valley of the Arkansaw. In the sides of these deep canals the rocks are so exposed as to afford convenient opportunities for examining a short distance into the internal structure of the plain. Here as in the other districts which we have mentioned, the lowest and almost the only rock found in the plains is sandstone. This we shall consider as of two varieties, though we do not doubt that those who are fond of system and of calling by different names things which are essentially the same, would be at no loss to discover here every variety of sandstone hitherto described, and perhaps many more.

1. Red sandstone. This rock which is the lowest of the horizontal or secondary rocks here met with, is very abundant in all that part of the plain immediately subjacent to the Rocky Mountains which we have had the opportunity to examine. A similar rock is met with in the eastern part of the State of New York, and is there, as in the instance of which we are speaking, placed near the borders of this great secondary formation. I have never met with it in the eastern part of the Mississippi valley. It occupies the country about the Canadian River, occurring on both sides most of the way from its sources to its confluence with the Arkansaw. It appears at intervals along the feet of the Rocky Mountains, reposing against the primitive in a highly inclined position. It varies in colour from vermilion red to dark brown, and sometimes to various shades of yellow and grey. Its cement is however almost invariably ferruginous, and the predominance of red in the colouring certainly entitles it to the distinctive appellation of red sandstone. The lowest

part of the stratum has frequently least colour, and is also most compact and hard. This is not however invariably the case; for about the Platte, that part of it which lies immediately upon the granite is white, and contains numerous and extensive beds of coarse puddingstone. About the Canadian, and in other places where this rock still lies in its original horizontal position, the upper part of the stratum is soft, and pretty uniformly of a red or yellowish brown colour. It is disposed in immense horizontal strata or laminae, which when broken, transversely exhibit some tendency to separate into fragments of a cubic or rhombic form. In the face of the high precipices, are often seen broad stripes or belts of a lighter colour, conspicuously marked with reticular yellowish veins, which are of a substance similar to hornstone. The cross fracture of the rock of course varies with the fineness of the particles of sand of which it is composed. It is often even, and sometimes approaching to splintery. When divided in a direction parallel to the stratifications, it frequently exhibits small scales of mica; but these are not numerous. Specimens from many parts of this stratum are entirely similar to that which is quarried in New Jersey, and used in great quantities in the cities of New York, Albany, &c. for building. That of the Rocky Mountains usually contains less mica and in smaller scales; but in other respects is similar. The cement of this rock is sometimes argillaceous; but I believe this is by no means universal. Whether this sandstone is in all respects similar to the "Old Red Sandstone" of Werner,* which makes so conspicuous a figure in the systems of certain geologists, we are not able to say. It however certainly occupies a place similar to the one which has been assigned to that rock. It is the lowest of the flætz or horizontally stratified rocks, and it is perhaps not improbable that it may extend under a great part of the

* This red sandstone is first found on the waters of the lakes on the strait between Lake Huron and Lake Superior, and forms the fall called the Saut de St. Marie. Below that point of the tide water, it is generally limestone.

formation of secondary which we are now considering. We have already mentioned that in an horizontal position it covers a very extensive tract to the south west of the Arkansas, that it skirts the eastern side of the Rocky Mountains, rising at a great angle from beneath the superimposed strata. It also occurs in the Catskill Mountains, and in the Salt District in the western part of the State of New York, having a similar relation to the secondary rocks in that quarter. The old red sandstone of Werner has by some been referred to the rocks of transition, and considered as the most recent member of that class ; others have considered it as the oldest of the secondary. But it seems to have happened here, as in other parts of this yet imperfect science, that distinctions have been made, for which there is really no foundation in nature. The red sandrock now under consideration appears at one place with every character requisite to place it among the rocks of transition, at another it is manifestly secondary ; yet its continuity may be traced through minute shades of gradation, or by a sudden transition from one of these points to the other.

Immediately above the red sandstone, when any rock rests upon it, I have commonly found a greyish or yellowish white sandstone which may perhaps be with some propriety distinguished as the second variety. It commonly contains a greater or less proportion of clay in the cement, and has a somewhat slaty structure. Hence it may properly be called argillaceous sandstone, though in some respects it may differ from the rock known to many by that name.

2. Argillaceous sandstone. This variety being uppermost in actual position, is perhaps more frequently seen on the surface than the other ; while at the same time it is probably less abundant. The line of separation betwixt the two is often manifest and well defined, and in other instances they pass by imperceptible gradations into each other. The upper or argillaceous sandstone is usually more compact and more homogeneous in its composition than the red. It is also of a close texture and a fine grain, embracing few

foreign substances, and I believe in some rare instances, passing into a coarse or conglomerate puddingstone. It sometimes breaks into large rhombic masses (though in this case it must be acknowledged that it contains little or no clay,) and these, on account of a more compact texture, retain their form longer than similar masses of the other. The precipices formed by both are frequently lofty and perpendicular, but the projections and angles of the red are more worn and rounded than those of the variety now under consideration. The narrow defiles and ravines which the streams of water have excavated, are less tortuous as well as narrower, when made entirely in this rock, than in other instances. The springs of water which it affords are sometimes saline, but more commonly free from mineral impregnations than such as are found issuing from the other variety. It sometimes consists of glittering crystalline particles, but does not in this case appear to be a chemical deposit. In fine, it appears under an almost endless variety of characters, which it would be in vain to attempt to enumerate. Though not invariably distinguished by the presence of an argillaceous ingredient, yet this is often the case, and it is constantly found accompanying the beds of soft clay slate or bituminous shale, whenever these occur. Whether coal accompanies these beds in the neighbourhood of the Rocky Mountains, as it usually does in other places, we are unable to say. It is however certain that they contain similar impressions of vegetables, and in other respects closely resemble the bituminous shale of many coal districts. About the sources of the Canadian, this shale occurs in very narrow horizontal beds, and contains charred vegetable matter which could not readily be distinguished from common charcoal.

If this formation of sandstone, consisting of the two varieties just mentioned, ever extended across the valley of the Mississippi to the Alleghany Mountains, as some might be disposed to imagine, I cannot pretend to determine what was

the position it occupied relative to the immense masses of flœtz limestone and other secondary rocks which are now found in that valley.

But as the red variety is still extensively disseminated, and usually accompanied by those valuable substances, salt and plaister, (sulphate of lime) it may not be amiss to trace, as far as our examinations have enabled us to do it, the outline of the region it occupies.

As we have before mentioned, it is found in the vicinity of the river Platte, in a highly inclined position, covering a narrow margin, immediately at the foot of the Rocky Mountains. From the account of Lewis and Clarke, we are disposed to believe that it exists under similar circumstances near the falls of the Missouri. On the Canadian, it is constantly met with from the sources of that river, which are on the borders of New Mexico in west longitude about 106 degrees, nearly to its confluence with the Arkansaw, in 97 degrees. The waters of the Canadian, from flowing over the sandstone in question, acquire an intense red colour, and are so impregnated with muriate of soda and other soluble salts, as to be unfit for the uses to which common water is applied. This, it is well known, is also the case with the waters of the three small rivers tributary to the Arkansaw, above the Canadian, on the same side also with the waters of Red River. Hence the conclusion appears to be justified, that this rock extends from near the Arkansaw on the north to a point beyond Red River on the south, and from near the mouth of the Canadian an unknown distance to the west beyond the remotest sources of that river. It is not unlikely that it exists about the sources and upper branches of the Rio Colorado of California, though we must acknowledge that the name of that river is the only foundation we are acquainted with for such an opinion.

Near the mountains at the head of the Platte, and for a great distance to the south and east of the high peak, the red sandrock is covered by the stratum of argillaceous sandstone already mentioned. It has, however, in many in-

stances, been laid bare by the action of water, which has worn away the superincumbent stratum, as is the case on the Vermilion River, a branch of the Platte which rises in the plains at a considerable distance to the east from the peak. This argillaceous or grey sandstone is the uppermost of those horizontally stratified rocks which are seen in this region, possessing within themselves convincing evidence of their having been formed by deposition from the waters of the ocean.

Another family of rocks of recent, but doubtful, origin, which are usually found resting on the sandstone last mentioned, remains to be considered. These are rocks of basaltic or trappean conformation, by some geologists denominated superincumbent rocks, and by many supposed to be of volcanic origin.

They present a striking contrast by their dark colour, and the vastness and irregularity of their masses, to the smooth, light, and fissile sandstone on which they rest. In their texture and external conformation they often make a nearer approach to the primitive rocks than to those denominated secondary among which they occur. Their appearance and position are such as to lead almost involuntarily those least attached to visionary theories into speculations concerning their origin. Sometimes they are observed compact and apparently homogenous in their composition, presenting a crystalline rather than a stratiform appearance, and in many particulars of structure, form, hardness, colour, &c. seeming closely allied to the rocks of primitive formation. In other instances, black and semivitrified substances are seen scattered about the plains, or heaped in conic masses, but never approaching in character the rocks on which they rest. Most of the rocks of this sort which were observed, are found in the country about the sources of the Canadian River. Among them may be distinguished two kinds referable to two divisions of the class called by Werner superincumbent rocks, viz. greenstone and amygdaloid.

1. Greenstone. Grünstein, *Wern.* Roche amphibol-

lique, *Haüy*. It appears, in the limited district which we examined, under almost every variety of form and character ever noticed by geologists. Sometimes it is nearly free from any intermixture of hornblende, and is of a fine dark green colour, nearly resembling some varieties of serpentine.

Its minute structure is often manifestly crystalline; in which case its fracture is granular. In other instances its particles are not perceptibly crystalline, and the fracture is earthy. Sometimes its colour is a dull grey, graduating into brown and black of various shades and intensities. This rock forms numerous conic hills of considerable elevation, which are irregular in height, and scattered without order in various parts of the plain. These hills are usually of a regular and beautiful form. The great plain in which they stand is elevated, and destitute of timber or water, but ornamented with a thick and verdant carpet of grasses and other herbacious plants. The hills, though steep and high, are smooth and green to the summit, their surface being nearly unbroken by rocks, and covered with thick turf. The whole forms a scene of singular beauty. During our journey across that district of country which is based upon the rocks now under consideration, we had constant occasion to admire the exuberance and freshness of vegetation. The plains of the Platte and Arkansaw we had seen brown and desolate as if recently ravaged by fire, yet here we passed elevated tracts having a scanty soil, and scarcely affording water for our necessities, yet the vegetation possessed the freshness of spring in the most fertile regions.

The conic hills above mentioned are not the only nor indeed the most common form under which the greenstone appears. It sometimes forms low ridges extending a considerable distance, and sloping gradually on both sides into the level of the plain. In the narrow channels which the streams of water have sunk in it may be seen perpendicular precipices of considerable elevation; but the valleys are usually much obstructed by large broken masses of the rock

which sometimes exhibit a prismatic form. It falls readily into large angular fragments, but seems strongly to resist that progress of disintegration which it must undergo before it can be removed by the water. The face of the perpendicular precipices which it forms is often marked by large parallel vertical seams. Following the water courses, which are sunk a considerable distance below the surface, the line of separation from the sandstone on which the greenstone rests at length becomes visible. The sandrock in these places has its strata nearly or quite horizontal, and in all other characters is similar to what we have formerly mentioned.

2. Amygdaloid, *Kirwan*. Mandelstein, *Werner*. Roche amygdaloïde, *Brochant*.

We apply this name to a porous or vesicular rock of a very dark grey, greenish, or black colour, usually accompanying the greenstone, and sometimes in connection with the sandstone. In its ultimate composition it resembles greenstone, but I have never seen in it such large fragments of feldspar and scales of mica as are observed in that rock. The cavities which occur in every part of the substance of this rock are of various sizes, some of them having the appearance of bubbles which had been formed in a semifluid mass and afterwards lengthened and variously distorted by the motions of the contiguous matter. Near the surface they contain a soft white or yellowish carbonate of lime nearly filling the cavity and giving to the recent surface a variegated or spotted appearance. In surfaces which have for some time been exposed to the air, this soft substance has been removed, and the little cavities are found empty.

Amygdaloid does not appear to occupy any great extent of the country near the Rocky Mountains. I have not met with it imbedded in, or surmounted by, any other rock. It forms conic hills like the greenstone before mentioned, and these sometimes occur in deep waterworn valleys bounded on both sides by precipices of sandrock rising much above the elevation of the amygdaloid. It is likewise seen in the high plains, sometimes in narrow and crooked ridges, as if

following the direction of what were formerly the beds of small brooks. This appearance was in one instance so striking, that several of the party who saw it were induced to believe that the materials which constituted the ridge had formerly been ejected in a fluid state from beneath the surface. We had not an opportunity to examine the surrounding country with sufficient minuteness to enable us to form a conjecture concerning the accuracy of this opinion. Some high and sharp conic hills were visible to the westward, but at a great distance. Two of this kind, which stand near each other and appear to be detached from the primitive mountain, are called the Spanish Peaks, and at the end of July, snow was still to be seen on them.

Where either of the two rocks last mentioned occur, it is not uncommon to meet with detached masses of a substance greatly resembling the pumice stone, which is an article of commerce, and entirely similar to that which is often seen floating down the Missouri. It is usually of a faint red or dirty yellow colour, but sometimes brown or nearly black. It feels less harsh than common pumice stone, and is composed almost wholly of clay.

With regard to the alluvial formations of the portion of country of which we have been speaking, little need be said. The trap rocks are often covered with a scanty dark coloured soil, free from pebbles or waterworn masses, and of considerable fertility.

The sandstone districts are often covered to a great depth with rounded fragments and particles of rocks similar to those of the primitive mountains. The fineness of this soil bears a pretty constant proportion to the distance from the mountain at which it is examined. On the lower part of the Platte scarce a stone or a pebble is to be seen. At a distance of two hundred miles from the mountain the surface is often like a gravelled walk or a street paved with pebbles, and near the foot of the mountain it is covered with large boulders. The soil is almost invariably arid and barren. The total absence of any formation of limestone in the dis-

trict of country under consideration, will not fail to be remarked, but I believe is also common to several other similar districts. A traveller to the upper part of the Missouri mentions "calcareous and petrosilicious hills" as existing in the coal formations on that river. But in ascending the Platte from its confluence with the Missouri, not a fragment of limestone or petrosilex is to be seen. Small veins of carbonate of lime, crystallised in the usual form, are found in the argillaceous sandstone of the Arkansaw. Also the sulphate in small quantities. Gypsum is very abundant on the Canadian River at the distance of three or four hundred miles from its sources. It is disseminated in veins and in thick horizontal beds in red sandstone. The extent and thickness of these horizontal beds are perhaps such as would justify the appellation of stratum, but as it is not met with in great quantities, except in connection with this sandstone, with which it often alternates, it may with propriety be considered as a subordinate rock.

Rock salt. It has been often and confidently asserted, that this substance exists in some part of Upper Louisiana in the form of an extensive stratum.

I have met with it among the natives in masses of twenty or thirty pounds weight. These, of which I have seen only two, were about six inches in thickness and eighteen or twenty in diameter. They were in the possession of an Arikara who lives among the Paunees of the Loup Fork, and when we saw him, was on his return from an excursion to the Arkansaw. The interior of these masses, when broken, presented a crystalline structure, being made up of incomplete cubic crystals variously grouped together. On one of the surfaces of the mass, which had probably been the one in contact with the ground or rock on which the salt had rested, a considerable mixture of red sand was discoverable. These masses, it is highly probable, had been produced by the evaporation, during the dry season, of the waters of some small lake. The Indians who wander near the mountains

had considerable quantities of salt, which was in the form of large detached crystals, and seemed to have been formed in the same manner as the other. They said it came from the south west, and as we understood them, from some of the upper branches of Red River.

The whole country near the mountains abounds in licks, brine springs, and saline efflorescences; but it is in the neighbourhood of the red sandrock that salt is met with in the greatest abundance and purity.

The immediate valley of the Canadian River, in the upper part of its course, varies in width from a few rods to three or four miles, but is almost invariably bounded by precipices of red sandrock, forming what are called the river bluffs. On the valley between, these incrustations of nearly pure salt are often found covering a considerable extent of surface, in the manner of a thin ice, and causing it to appear when seen from a distance, as if covered with snow.

Most of the remarkable formations of rock salt hitherto known in various parts of the world are contained in what is denominated the lowest red sandstone which appears to correspond in character, position, &c. with the sandrock above mentioned. In this connection it is found in Cheshire, at Northwich and Droitwich in England, at the feet of the Carpathian Mountains in Poland, and in Peru. Accident, or further examination, it is probable, may hereafter bring to light those extensive beds of this substance which there is every reason to believe exist in the neighbourhood of the Rocky Mountains.

The briny character of those two great streams, the Arkansas and Red River, flowing from this district of country, scarcely permits us to call in question the existence of such repositories; and the greatness of the quantity of salt which those rivers have for ages been washing away, would lead us to conclude that its beds must be of great extent. Analogy would teach us to look for them in depressed situations and in bason-shaped concavities, whose contents had not yet been worn down and removed by currents of water.

Other rocks of secondary formation are found in the great valley of the Mississippi, but have not been observed in that portion of it of which we have been speaking. These will be noticed at another time.